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TITLE: SUPERCONDUCTIVE WIRE ROD

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ABSTRACT:

PURPOSE: To provide a superconductive wire adaptable to formation of a superconducting coil and the like, which allows an alternating current of commercial frequency of the same degree as a direct current to flow therethrough and at the same time provides the low loss of an alternating current.

CONSTITUTION: In a superconductive wire 4' which permits conduction of a large current by twisting a plurality of superconductive strands 1 of NbTi embeded into a matrix material on the circumference of a central wire 5a to make it in one body, the central wire 5a (5b, 5c) is characterized by a hollow wire made of stainless steel or CuNi of Ni concentration not larger than 40wt.%. According to this invention, it is preferable that the NbTi superconductive stands 1 to form a twisted wire with the hollow central wire 5a (5b, 5c) made an axis is a NbTi filament not larger than 1μm in diameter embeded into the matrix material and that the thickness of the hollow central wire 5a (5b, 5c) to be a twisted wire is degrees not larger than 1/4 (the diameter of a hollow is not larger than 1/4 of that of a hollow wire), since it makes smaller eddy current loss and a coupling loss between a superconductive strand and a central wire and besides makes higher its resistance after quenched.

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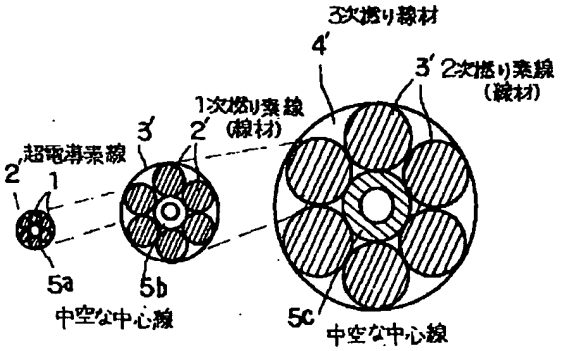
(54)【発明の名称】　超電導線材

(57)【要約】

【目的】　商用周波数の交流でも直流と同程度の電流を流すことが可能で、かつ交流損失なども低くて超電導コイルなどの構成に適する超電導線材の提供を目的とする。

【構成】　中心線5a(5b,5c) の周面にマトリックス材に埋め込まれたNbTiの超電導素線１複数本を列状に撚り一体化して大電流の通電を可能にする超電導線材４′において、前記中心線5a(5b,5c) がステンレス製もしくはNi濃度40wt%以下のCuNi製の中空線であることを特徴とする。本発明において、中空な中空線5a(5b,5c) を軸として撚り線を構成するNbTi超電導素線１は、マトリックス材に埋め込まれたNbTiフィラメント径が 1μm 以下であることが望ましく、また、撚り線の中空な中心線5a(5b,5c) は、渦電流損失や超電導素線－中心線間結合損失を小さくする一方、クエンチ後の抵抗を高くするため、前記中空な中空線5a(5b,5c) の肉厚は1/4 以下（中空の径は中空線径の1/2 以下）程度が好ましい。



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【特許請求の範囲】

【請求項１】　中心線の周面にマトリックス材に埋め込まれたNbTiの素線複数本を列状に撚り一体化して大電流の通電を可能にする超電導線材において、

前記中心線がステンレス製もしくはNi濃度40wt%以下のCuNi製の中空線であることを特徴とする超電導線材。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、商用周波数の交流もしくは直流でも同程度の電流を流し得る低損失超電導線材に係り、特に交流通電時とクエンチ時における液体ヘリウムの消費量も低減可能な超電導コイルの構成に適する超電導線材に関する。

【０００２】

【従来の技術】周知のように、超電導線は電気抵抗が非常に小さいため、直流的には微小なジュール熱損で電流を流し得る。一方、この種の超電導線は、変動磁場中で電流を流そうとすると、主にヒステリシス損失および結合損失からなる交流損失を生じる。したがって、この種の超電導線を商用周波数50Hzもしくは60Hzで使用する場合、たとえば超電導コイルなどとして実用化するとき、前記交流損失のうち特にヒステリシス損失をどこまで低減し得るかが重要な課題となる。

【０００３】ところで、前記ヒステリシス損失は、超電導素線を構成する超電導フィラメント径、換言すると安定化材として機能するマトリックス中の超電導フィラメント径に比例することに着目し、超電導フィラメント径の微小化が進められており、量産的な規模でも超電導フィラメント径 1μm 以下が達成されている。しかし、前記超電導フィラメント径を微小化しながら、直流用超電導線並の臨界電流値を得ようとすると超電導フィラメントの本数を多く、また直流用超電導線並の臨界電流密度を得ようとすると超電導フィラメント相互の間隔を小さく、それぞれ設定する必要がある。一方、前記超電導フィラメント相互の間隔が、マトリックス材のコヒーレンス長以下になると、近接効果により隣り合うフィラメント同士の結合が生じ、等価的な超電導フィラメント径が大きくなるので、ヒステリシス損失は設けられた各超電導フィラメント径から予想される値よりも大きくなる。したがって、前記構成においては、近接効果によるフィラメント同士の結合を生じない最低の超電導フィラメント間隔に設定しなければならない。つまり、交流で大電流を流し得る交流用超電導線材としては、近接効果によるフィラメント同士の結合を生じない最低の超電導フィラメント間隔に選択・設定して成る超電導素線の複数本を、撚り合わせた構成として実用に供している。たとえば図２に断面構成を模式的に示すように、 7本の超電導素線１を撚り合わせ構成した１次撚り超電導素線（線材）２、この超電導素線２を 7本撚り合わせ構成した２次撚り超電導素線（線材）３、さらに２次撚り超電導素

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線３を 7本撚り合わせ構成した３次撚り超電導線材４とした形で実用されている。なお、前記超電導線材４の構成においては、 1本が中心線となりこの中心線の周面に他の 6本を列状に撚り合わせた態様を成しているが、むくのステンレス線やCuNi線を中心線とし、 6本の超電導素線１を列状に撚り合わせた構成とすることも知られている。

【０００４】

【発明が解決しようとする課題】しかしながら、前記構成の撚り合わせ超電導線材の場合、実用上次のような不都合な問題があった。たとえば前記超電導素線１を 7本撚り合わせ構成の超電導線材２において、中心線も超電導素線１′の場合、商用周波数50Hzもしくは60Hzの交流を通電する際、 7本の超電導素線間の相互インダクタンスの非対称性から、中心線を成す超電導素線１′には通電電流と逆向きの電流が流れる可能性がある。つまり、この構成の場合は、直流と同程度の電流を通電し得ないという問題がある。こうしたことは２次撚り超電導線材３や３次撚り超電導線材４の場合も同様である。

【０００５】一方、むくのステンレス線やCuNi線を中心線とし、 6本の超電導素線１を撚り合わせた構成の超電導線材の場合、２次以上に撚るに伴いその中心線の径が大きくなるため、商用周波数50Hzもしくは60Hzの交流を通電する際、中心線を成すステンレス線やCuNi線の渦電流損失や超電導素線－中心線間結合損失が大きくなってくる。そして、この渦電流損失や超電導素線－中心線間結合損失が大きくなると、超電導線材（導体）の温度が上昇し、直流と同程度の電流を通電し得なくなる。特に、この種の超電導線材を超電導コイルの構成に用いた場合、前記渦電流損失や超電導素線－中心線間結合損失に伴い、通電・駆動中における液体ヘリウムの消費量増大を招来するという問題がある。しかも、この液体ヘリウムの消費量の問題は、超電導コイルの通電・駆動中だけでなく、クエンチ後においても重要な課題であり、クエンチ時に超電導線材が高抵抗を呈することが必要であるのに、前記構成の超電導線材はこのような機能を備えていない。

【０００６】本発明は、上記事情に対処してなされたもので、商用周波数の交流でも直流と同程度の電流を流すことが可能で、かつ交流損失なども低くて超電導コイルなどの構成に適する超電導線材の提供を目的とする。

【０００７】

【課題を解決するための手段】本発明に係る超電導線材は、中心線の周面にマトリックス材に埋め込まれたNbTiの超電導素線複数本を列状に撚り一体化して大電流の通電を可能にする超電導線材において、前記中心線がステンレス製もしくはNi濃度40wt%以下のCuNi製の中空線であることを特徴とする。　本発明において、中空線を軸として撚り線を構成するNbTi超電導素線は、マトリックス材に埋め込まれたNbTiフィラメント径が 1μm 以下で

あることが望ましい。また、撚り線の中心線は、渦電流損失や超電導素線－中心線間結合損失を小さくする一方、クエンチ後の抵抗を高くするため、前記のように中空線であることが必要で、またその中空線の肉厚は1/4以下（中空の径は中空線径の1/2 以下）程度が好ましい。そして、中心線がCuNi製の中空線の場合においては、Ni濃度（成分比）40wt%以下のものが常に選択される。その理由はNi濃度40wt%以上とすると、Niが磁気モーメントを持つようになって、マトリックスとし使用するのに不適当となるからである。

【０００８】

【作用】本発明に係る超電導線材は、複数本のNbTi超電導素線を周面に列状に撚り一体化する中心線を、比抵抗の高いステンレス製もしくはNi濃度40wt%以下のCuNi製の中空線としたことにより、その周面に列状に撚り一体化されたNbTi超電導素線間のインダクタンスのアンバランスが解消されるので、中心線を逆向きの電流が流れることもなくなる。特に、前記中空線の肉厚を1/4 以下（中空の径は中空線径の1/2 以下）に設定した場合は、中心線の断面積に比例する渦電流損失や超電導素線－中心線間結合損失が小さくなり、温度上昇も抑制されるため、交流通電中の液体ヘリウム（極低温用冷媒）消費量を低減し得る。また、中心線の実質的な断面積の低減により、“比抵抗×長さ÷断面積”で決まるクエンチ後の抵抗も増加し、“電圧^2 ÷抵抗”で決まるジュール熱による液体ヘリウムの消費量も低減される。

【０００９】

【実施例】次に、本発明の実施例について図１を参照して説明する。

【００１０】図１は本発明に係る超電導線材において、6^3 型にNbTi超電導素線撚りした断面構成を模式的に示したものである。図１において、5aは中空な中心線で、たとえば直径0.1 ㎜，肉厚0.05㎜のステンレス製パイプ、１は前記ステンレス製パイプ5aの周面に列状に撚り付け一体化された 6本のNbTiの超電導素線で、たとえばCuNi系などをマトリックス材として直径0.6 μ㎜ のNbTiフィラメントを埋め込んでなる直径0.1 ㎜の超電導素線であり、この超電導素線１の撚り合わせで１次撚り超電導素線２′が構成されている。また、この１次撚り超電導素線２′ を 6本、たとえば直径0.3 ㎜，肉厚0.15㎜のステンレス製パイプ5bの周面に列状に撚り合わせ構成した２次撚り超電導素線３′が構成されている。さらに、前記２次撚り超電導素線３′ を 6本、たとえば直径0.9 ㎜，肉厚0.45㎜のステンレス製パイプ5cの周面に列状に撚り合わせ構成した３次撚り超電導線材４′が構成されている。　上記のように構成された 6^3 型の短尺なNbTi超電導線材４′ に、50Hzの交流を通電したところ、直流の臨界電流と同じ4000 Aを流すことができた。一方、この 6^3 型のNbTi超電導線材４′ を用いて超電導コイルを構成し、この超電導コイルに50Hzの交流を通電したところ、直流の臨界電流と同じ1498 Aを流すことができた。また、この超電導コイルのクエンチ後の液体ヘリウムの消費量も 2リットルと小さかった。

【００１１】このように、本発明に係る超電導線材では、交流通電時とクエンチ時の液体ヘリウムの消費量を大幅に低減できるので、特に超電導コイルを応用した超電導限流器のように超電導線のクエンチ現象を利用する機器においては、交流通電時とクエンチ時の液体ヘリウムの消費量が少なくなるので有効である。

【００１２】なお、本発明に係るNbTi超電導線材の構造ないし構成は、前記例示の形態に限定されるものでない。すなわち、 6^3 型以外の構造ないし構成でもよく、また、中心線を成す中空線のステンレス製パイプの直径，肉厚なども任意に選択・設定し得るし、ステンレス製パイプの代わりにNi濃度40wt%以下のCuNi製パイプを用いても同様の効果が得られる。

【００１３】

【発明の効果】以上説明したように本発明に係る超電導線材は、NbTi超電導素線間のインダクタンスのアンバランスが解消されので、中心線を逆向きの電流が流れることもなくなる。したがって、渦電流損失や超電導素線－中心線間結合損失が小さく抑制されるため、温度上昇も大幅に低減されるので、交流通電中の液体ヘリウム（極低温用冷媒）消費量が低減される。つまり、中空線を軸として撚り線を構成するNbTi超電導素線のNbTiフィラメント径が 1μ㎜ 以下で、中空線の肉厚は1/4 以下（中空の径は中空線径の1/2 以下）程度に設定することにより、渦電流損失や超電導素線－中心線間結合損失が小さくなる一方、クエンチ後の抵抗が高くなるため、交流通電中は勿論のことクエンチ後の液体ヘリウム（極低温用冷媒）消費量も低減し得る。しかも、交流通電の臨界電流値も直流通電の場合と同程度とすぐれた性能を呈する。

【図面の簡単な説明】

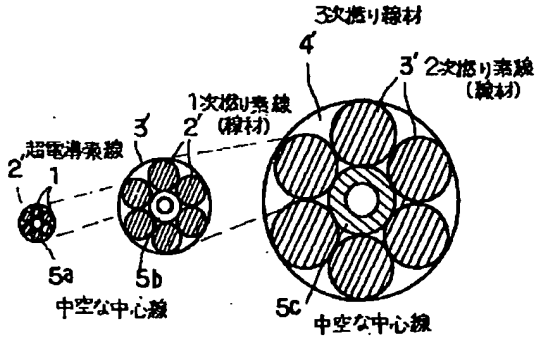
【図１】本発明に係る超電導線材の断面構造例を示す模式図。

【図２】従来の超電導線材の断面構造例を示す模式図。

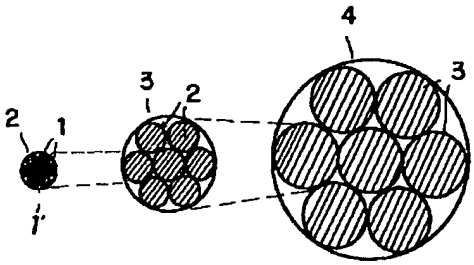
【符号の説明】

1…NbTi超電導素線　　２，２′…１次撚り超電導素線　　３，３′…２次撚り超電導素線　　４，４′…３次撚り超電導素線（超電導線材）　　5a,5b,5c…中空な中心線

【図1】


3次撚り線材
4'
3'
2次撚り素線
(線材)
1次撚り素線
(線材)
2'
3'
超電導素線
2
1
5a
5b
中空な中心線
5c
中空な中心線

【図2】


4
3
2
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1
i'

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(54) SUPERCONDUCTIVE WIRE ROD

(57)Abstract:

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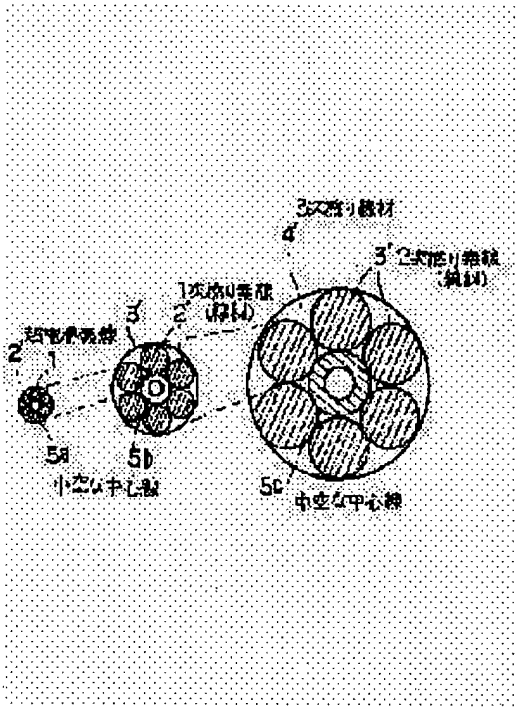
CONSTITUTION: In a superconductive wire 4' which permits conduction of a large current by twisting a plurality of superconductive strands 1 of NbTi embeded into a matrix material on the circumference of a central wire 5a to make it in one body, the central wire 5a (5b, 5c) is characterized by a hollow wire made of stainless steel or CuNi of Ni concentration not larger than 40wt.%.



According to this invention, it is preferable that the NbTi superconductive stands 1 to form a twisted wire with the hollow central wire 5a (5b, 5c) made an axis is a NbTi filament not larger than 1μm in diameter embeded into the matrix material and that the thickness of the hollow central wire 5a (5b, 5c) to be a twisted wire is degrees not larger than 1/4 (the diameter of a hollow is not larger than 1/4 of that of a hollow wire), since it makes smaller eddy current loss and a coupling loss between a superconductive strand and a central wire and besides makes higher its resistance after quenched.

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[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

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CLAIMS

[Claim(s)]
[Claim 1] The superconduction wire rod characterized by said center line being a product made from stainless steel, or a hollow line made from CuNi not more than nickel concentration 40wt% in the superconduction wire rod which twists to seriate strand two or more books of NbTi embedded by the matrix material at the peripheral surface of a center line, unifies, and enables energization of a high current.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the superconduction wire rod suitable for the configuration of the superconduction coil which can be applied to the low loss superconduction wire rod which can pass a comparable current also by an alternating current or direct current of commercial frequency, especially can also reduce the consumption of the liquid helium at the time of alternating current energization and quenching.
[0002]
[Description of the Prior Art] As everyone knows, since a superconduction line has very small electric resistance, a current can be passed by Joule's heat loss minute in direct current. On the other hand, this kind of superconduction line will produce the AC loss which mainly consists of hysteresis loss and joint loss, if it is going to pass a current all over a fluctuation magnetic field. Therefore, when putting in practical use as a superconduction coil etc. when using this kind of superconduction line by the commercial frequency of 50Hz, or 60Hz for example, it becomes an important technical problem how far hysteresis loss can be reduced especially among said AC losses.
[0003] By the way, paying attention to being proportional to the diameter of a superconduction filament which constitutes a superconductive element line, and the diameter of a superconduction filament in the matrix which will function as stabilization material if it puts in another way, micrifying of the diameter of a superconduction filament is advanced and said hysteresis loss is a diameter of a superconduction filament also at a mass-production-scale. 1 micrometer The following is attained. However, micrifying said diameter of a superconduction filament, if when it is going to acquire the critical current value of superconduction **** for a direct current and it is going to obtain the critical current density of superconduction **** for a direct current, it is small and it necessary to set up spacing between superconduction filaments, respectively. [number / of a superconduction filament] On the other hand, if spacing between said superconduction filaments becomes below the coherence length of a matrix material, since association of the filaments which adjoin each other according to the proximity effect will arise and the equivalent diameter of a superconduction filament will become large, hysteresis loss becomes larger than the value expected from each prepared diameter of a superconduction filament. Therefore, in said configuration, it must be set as the minimum superconduction filament spacing which does not produce association of the filaments by the proximity effect. That is, practical use is presented with two or more [of the superconductive element lines which choose and set up and grow into the minimum superconduction filament spacing which does not produce association of the filaments by the proximity effect as a superconduction wire rod for an alternating current which can pass a high current by alternating current] as a twisted configuration. as [show / a cross-section configuration / for example,, / in drawing 2 / typically] -- the primary twist superconductive element line (a wire rod) 2 which twisted seven superconductive element lines 1 and constituted them, and this superconductive element line 2 The secondary twist superconductive element line (wire rod) 3 and the secondary [further] twist superconductive element line 3 which twisted seven and constituted It uses in the form

which twisted seven and was used as the constituted 3rd twist superconduction wire rod 4. in addition, it sets in the configuration of said superconduction wire rod 4 -- one -- a center line -- becoming -- the peripheral surface of this center line -- others although the mode which twisted six to seriate is accomplished, let a pure stainless steel line and a CuNi line be center lines -- considering as the configuration which twisted six superconductive element lines 1 to seriate is also known.
[0004]
[Problem(s) to be Solved by the Invention] However, said configuration twisted and, in the case of a doubling superconduction wire rod, there were the practically following inconvenient problems. For example, said superconductive element line 1 To superconductive element line 1' which accomplishes a center line, an energization current and the current of the reverse sense may flow from the asymmetry of the mutual inductance between seven superconductive element lines the time of twisting seven and a center line also energizing the commercial frequency of 50Hz, or a 60Hz alternating current in the superconduction wire rod 2 of a doubling configuration in superconductive element line 1'. That is, in this configuration, there is a problem that a current comparable as a direct current cannot be energized. The same of such a thing is said of the case of the secondary twist superconduction wire rod 3 or the 3rd twist superconduction wire rod 4.
[0005] on the other hand, let a pure stainless steel line and a CuNi line be center lines -- since it follows on twisting more than to the 2nd order in the case of the superconduction wire rod of a configuration of having twisted six superconductive element lines 1 and the path of the center line becomes large, in case the alternating current which is the commercial frequency of 50Hz or 60Hz is energized, the eddy current loss of the stainless steel line which accomplishes a center line, or a CuNi line, and superconductive element line--center line joint loss become large. When this eddy current loss and superconductive element line--center line joint loss become large, the temperature of a superconduction wire rod (conductor) rises and it becomes impossible and to energize a current comparable as a direct current. When this kind of superconduction wire rod is especially used for the configuration of a superconduction coil, it follows on said eddy current loss or superconductive element line--center line joint loss, and there is a problem of inviting consumption increase of the liquid helium under energization / drive. And although the problem of the consumption of this liquid helium requires that it should be an important technical problem and a superconduction wire rod should present high resistance at the time of quenching not only under energization / drive of a superconduction coil but after quenching, the superconduction wire rod of said configuration is not equipped with such a function.
[0006] This invention coped with the above-mentioned situation, was made, can pass a current also with the alternating current of commercial frequency comparable as a direct current, and aims AC loss etc. at offer of the superconduction wire rod which is low and fits the configuration of a superconduction coil etc.
[0007]
[Means for Solving the Problem] The superconduction wire rod concerning this invention is characterized by said center line being a product made from stainless steel, or a hollow line made from CuNi not more than nickel concentration 40wt% in the superconduction wire rod which twists to seriate superconductive element line two or more books of NbTi embedded by the matrix material at the peripheral surface of a center line, unifies, and enables energization of a high current. In this invention, the diameter of a NbTi filament embedded at the matrix material the NbTi superconductive element line which constitutes a stranded wire centering on a hollow line 1 micrometer It is desirable that it is the following. Moreover, the center line of a stranded wire needs to be a hollow line as mentioned above, in order to make resistance after quenching high, while making small eddy current loss and superconductive element line--center line joint loss, and the thickness of the hollow line is one fourth. Extent is below (a path in the air is one half of hollow wire sizes following) desirable. And when a center line is a hollow line made from CuNi, the following [nickel concentration (component ratio) 40wt%] are always chosen. The reason is that nickel will become unsuitable coming to have the magnetic moment, considering as a matrix and using it if it carries out to more than nickel concentration 40wt%.

[0008]
[Function] Since the imbalance of the inductance between the NbTi superconductive element lines which twisted to the peripheral surface and were united with it by seriate by having made into the high product made from stainless steel of specific resistance or the hollow line made from CuNi not more than nickel concentration 40wt% the center line which twists two or more NbTi superconductive element lines to a peripheral surface seriate, and is unified is canceled, the superconduction wire rod concerning this invention becomes without the current of the reverse sense flowing a center line. Especially, it is the thickness of said hollow line One fourth Since the eddy current loss proportional to the cross section of a center line and superconductive element line--center line joint loss become small and a temperature rise is also controlled when it is set as below (a path in the air is one half of hollow wire sizes following), the liquid helium (refrigerant for very low temperature) consumption under alternating current energization can be reduced. Moreover, the resistance after quenching decided by the "specific resistance x die-length / cross-sectional area" also increases by reduction of the substantial cross-sectional area of a center line, and the consumption of the liquid helium by the Joule's heat decided by "electrical-potential-difference 2 / resistance" is also reduced.
[0009]
[Example] Next, the example of this invention is explained with reference to drawing 1 .
[0010] drawing 1 is set to the superconduction wire rod concerning this invention -- 63 The cross-section configuration which carried out the NbTi superconductive element line twist is typically shown in a mold. In drawing 1 , 5a was a hollow center line, for example, diameter 0.1 mm, the pipe made from stainless steel with a thickness of 0.05mm, and 1 were twisted to the peripheral surface of said pipe 5made from stainless steel a, and were united with it by seriate. They are six superconductive element lines of NbTi. For example, it is a diameter 0.6, using a CuNi system etc. as a matrix material. mum It is the superconductive element line of diameter 0.1 mm which comes to embed a NbTi filament, and this superconductive element line 1 twists and primary twist superconductive element line 2' consists of doubling. Moreover, this primary twist superconductive element line 2' Secondary twist superconductive element line 3' which twisted to the peripheral surface with a 6, for example, diameter 0.3 mm, and a thickness of 0.15mm of pipe 5made from stainless steel b, and was constituted in it seriate is constituted. Furthermore, said secondary twist superconductive element line 3' 3rd twist superconduction wire rod 4' which twisted to the peripheral surface with a 6, for example, diameter 0.9 mm, and a thickness of 0.45mm of pipe 5made from stainless steel c, and was constituted in it seriate is constituted. It was constituted as mentioned above. 63 When the 50Hz alternating current was energized to short length mold NbTi superconduction wire rod 4', the same 4000 A as the critical current of a direct current was able to be passed. on the other hand -- this -- 63 When the superconduction coil was constituted using NbTi superconduction wire rod 4' of a mold and the 50Hz alternating current was energized in this superconduction coil, the same 1498 A as the critical current of a direct current was able to be passed. Moreover, also consumption of the liquid helium after quenching of this superconduction coil It was as small as 2l.
[0011] Thus, in the device which uses the quenching phenomenon of a superconduction line like the superconducting-fault-current-limiting machine adapting especially a superconduction coil in the superconduction wire rod concerning this invention since the consumption of the liquid helium at the time of alternating current energization and quenching can be reduced sharply, since the consumption of the liquid helium at the time of alternating current energization and quenching decreases, it is effective.
[0012] In addition, the structure thru/or the configuration of a NbTi superconduction wire rod concerning this invention is not limited to the gestalt of said instantiation. Namely, 63 The diameter of the pipe made from stainless steel of the hollow line which the structure thru/or the configuration of those other than a mold is sufficient as, and accomplishes a center line, thickness, etc. can be chosen and set up at arbitration, and the same effectiveness is acquired even if it uses the pipe made from CuNi not more than nickel concentration 40wt% instead of the pipe made from stainless steel.
[0013]
[Effect of the Invention] The imbalance of the inductance between NbTi superconductive element lines

is canceled, it is **, and the superconduction wire rod applied to this invention as explained above becomes, without the current of the reverse sense flowing a center line. Therefore, since eddy current loss and superconductive element line--center line joint loss are controlled small and a temperature rise is also reduced sharply, the liquid helium (refrigerant for very low temperature) consumption under alternating current energization is reduced. That is, the diameter of a NbTi filament of the NbTi superconductive element line which constitutes a stranded wire centering on a hollow line 1 micrometer Below The thickness of a hollow line is one fourth. Since the resistance after quenching becomes high while eddy current loss and superconductive element line--center line joint loss become small by setting it as extent below (a path in the air being one half of hollow wire sizes following), The liquid helium (refrigerant for very low temperature) consumption after quenching can also be reduced not to mention under alternating current energization. And the engine performance which was excellent in the critical current value of alternating current energization being comparable as the case of the galvanization is presented.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The mimetic diagram showing the example of cross-section structure of the superconduction wire rod concerning this invention.
[Drawing 2] The mimetic diagram showing the example of cross-section structure of the conventional superconduction wire rod.
[Description of Notations]
1 -- NbTi superconductive element line 2 2' -- Primary twist superconductive element line 3 3' -- Secondary twist superconductive element line 4 4' -- 3rd twist superconductive element line (superconduction wire rod) 5a, 5b, 5c -- Hollow center line

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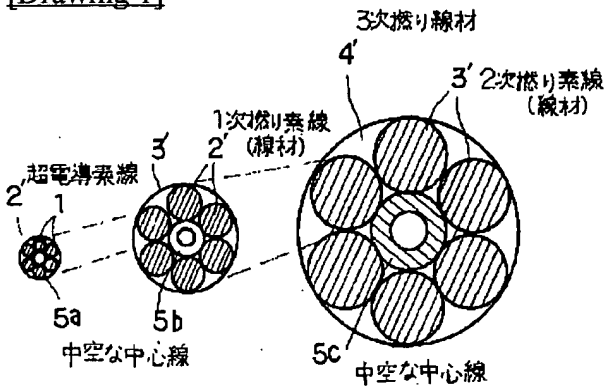
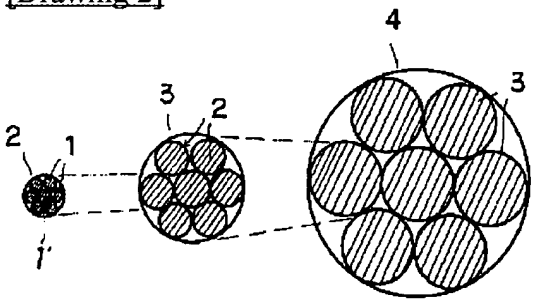
DRAWINGS

[Drawing 1]



[Drawing 2]



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